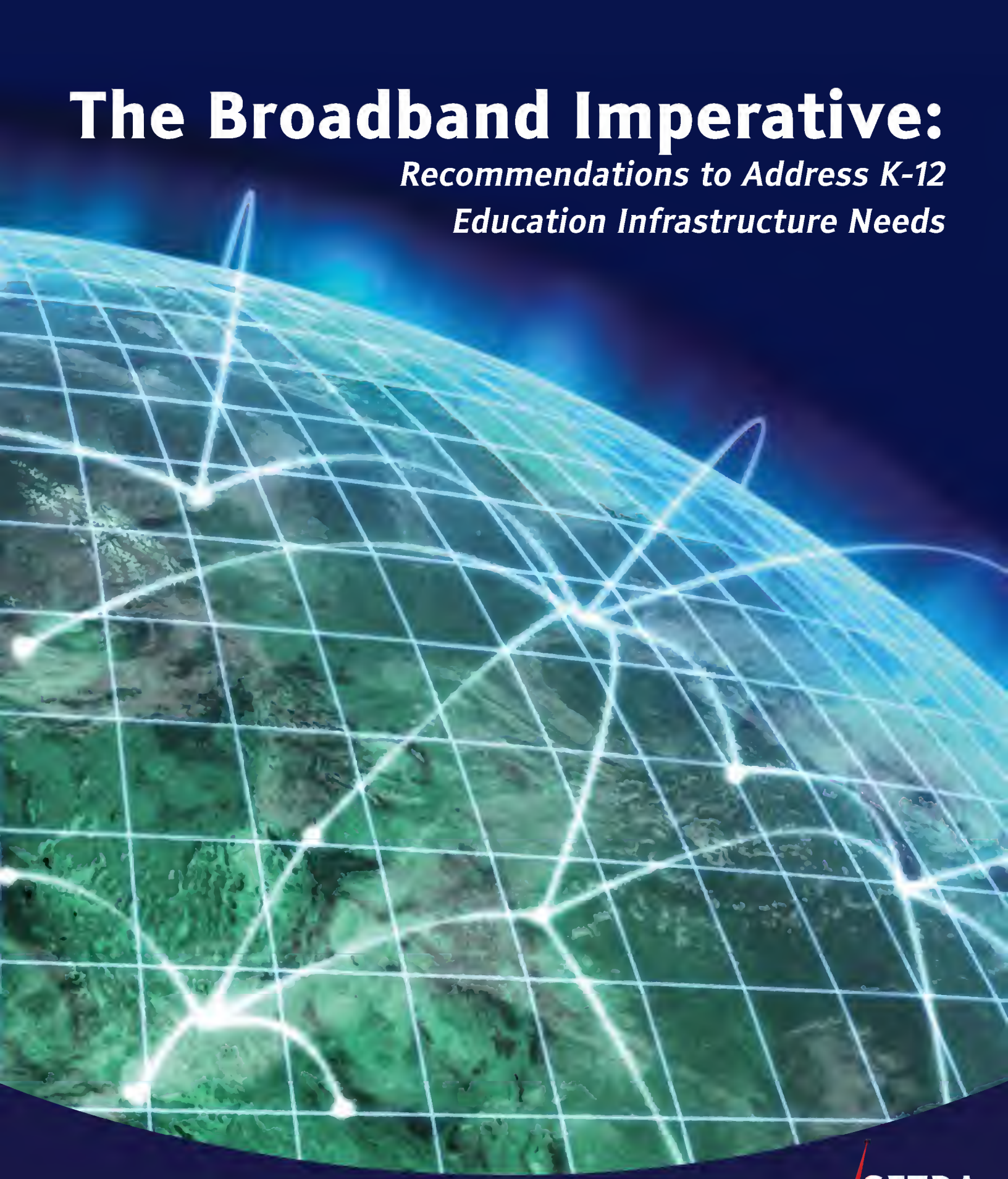
The Broadband Imperative:

Recommendations to Address K-12 Education Infrastructure Needs



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SETDA

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About the State Educational Technology Directors Association

Founded in the fall of 2001, the State Educational Technology Directors Association (SETDA) is the principal association serving, supporting, and representing U.S. state and territorial educational technology leadership. SETDA works in partnership with like-minded individuals and organizations as a forum for inter-state collaboration, cooperation, and best practices. Our work is funded by state membership dues, private sector contributions, charitable foundations, and the federal government. http://setda.org/

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EXECUTIVE SUMMARY

THE BROADBAND IMPERATIVE: RECOMMENDATIONS TO ADDRESS K-12 EDUCATION INFRASTRUCTURE NEEDS

It is a simple fact that access to high-speed broadband is now as vital a component of K-12 school infrastructure as electricity, air conditioning, and heating. The same tools and resources that have transformed our personal, civic, and professional lives must be part of learning experiences intended to prepare today's students for college and careers. College students rely on technology for academic success and to improve personal productivity.[1] In the workplace, everyone from mechanics to accountants to physicians depends on technology to conduct their work, grow their businesses, and collaborate with their colleagues – both locally and globally.

With easy access to reliable, robust, and cost-effective broadband, we can ensure that each student's school experience mirrors evolving societal expectations for public education. Access permits students to create engaging text and multimedia projects such as videos, collaboratively conduct research with students on the other side of the state or the world, take online courses not available locally, and talk directly with authors and experts. Teachers can collaborate with colleagues, participate in professional development online, and immediately analyze the results from online assessments to personalize instruction for each student.

Moreover, thanks to the proliferation of low-cost laptops, tablets, eReaders, and smartphones—and the rise of state and district high-access and 1-to-1 programs—teaching and learning is no longer limited to the confines of a school building or a school day. In fact, out-of-school access to broadband by students and teachers is now arguably as important to the overall quality of the student learning experience as access at school.

Unfortunately, the scope of the nation's educational broadband needs is large and growing rapidly. While a 2010 Federal Communications Commission survey of E-Rate funded schools found that most had access to some form of broadband service, nearly 80% of respondents reported that their broadband connections were inadequate to meet their current needs. Outside of school, home broadband adoption rates have all but stalled since 2009, leveling off at roughly 65%.

Given that bandwidth availability determines which online content, applications, and functionality students and educators will be able to use effectively in the classroom, additional bandwidth will be required in many, if not most, K-12 districts in this country in the coming years. If we are serious as a nation about preparing all students for college and careers, a concerted national effort will be required to address both school-based bandwidth needs and out-of-school access for students and educators.

Given current trends and the real-world experiences of states and leading districts, SETDA offers four recommendations for policymakers and school leaders committed to charting a course for the future of K-12 education enabled by broadband:

Recommendation 1: Move to Address K-12 Broadband Infrastructure Needs

To reach the goal of sufficient broadband access for enhanced K-12 teaching and learning and improved school operations as outlined in this report, SETDA recommends that schools and districts meet the following *minimum* bandwidth targets between now and the 2017-18 school year:

Broadband Access for Teaching, Learning and School Operations	2014-15 School Year Target	2017-18 School Year Target
An external Internet connection to the Internet Service Provider (ISP)	At least 100 Mbps per 1,000 students/staff	At least 1 Gbps per 1,000 students/staff
Internal wide area network (WAN) connections from the district to each school and among schools within the district	At least 1 Gbps per 1,000 students/staff	At least 10 Gbps per 1,000 students/staff

Recommendation 2: Ensure Broadband Access for Students and Educators

To reach the goal of universal broadband access by students and educators outside of school as outlined in this report, SETDA recommends the federal government, states, and districts take responsibility for ensuring easy access to robust broadband connectivity outside of schools including, but not limited to, the home and publicly accessible institutions to libraries and community centers.

Recommendation 3: Build State Leadership

SETDA recommends all states provide direct leadership in the development and implementation of programs to provide adequate and equitable bandwidth to K-12 schools, homes, and publicly accessible institutions, such as libraries and community centers. State leadership could entail expanding broadband coverage via the implementation of cost-effective state broadband networks and working in partnership with school districts to leverage federal and public-private partnership programs in support of a state's broadband needs.

Recommendation 4: Advocate for Federal Funding

SETDA recommends the federal government increase funding options to support a) states in implementing and maintaining high-speed broadband, statewide networks, b) districts and schools in increasing bandwidth capacity, c) communities in providing access points at anchor institutions including, but not limited, to libraries and community centers, and d) low-income families in providing home broadband access.

The Power of 24/7 Broadband Access

Sitting at the breakfast table, Sarah pulls out her laptop and logs onto her tenth grade biology class's wiki to see if her teacher has posted any comments regarding her group's latest project. She and three classmates have been collaborating to create a short multimedia presentation on the pollution levels in local creeks and streams. Her teacher has suggested downloading historical video clips from an open content site to add to the depth of their investigation. Soon her smartphone pings with an online calendar invitation to meet the group after school at the community center to refine their project. Jumping onto her personalized login page via the school's learning management system, she notices that her journalism teacher has posted the latest assignments and deadlines for the next edition of the school paper. Sarah is supposed to interview the basketball coach, but the team is traveling to the play-offs. She requests an online video chat while the coach is on the road so that she can meet Monday's deadline. She grabs her laptop and phone and dashes to catch the bus. First period is English and she doesn't want to miss the debate about students reading the original edition of Huckleberry Finn. During the debate, students will be chatting online about the debate and submitting questions to the moderator. After lunch, she sells tickets to this weekend's dance and frequently checks Twitter to see how many classmates are tweeting about the event. Later that day in math, after solving several sample questions from their digital geometry textbook, she takes an online formative assessment and then continues individualized practice based on the results of the assessment. At the end of the day, she adds her physical fitness stats from gym class into an app to help track her endurance progress and heads home to watch her teacher's latest Geometry video demonstration for homework.

Sarah's learning experience is more real than hypothetical for students attending schools where every student and teacher has ready access to technology and to robust broadband at school, at home, and throughout the community. For the rest of this nation's students, Sarah's technology-rich learning environment should be the furthest thing from hypothetical; since her day-in-the-life experience only mirrors the realities of ongoing shifts in our society.

Over the past decade, the Internet has fundamentally transformed our lives. We shop, bank, and socialize online. We download music and books, and stream movies and TV shows in real time. Even the Super Bowl is now presented live over the Internet. The same tools and resources that have transformed our personal, civic and professional lives must be part of learning experiences intended to prepare today's students for college and careers.

An Internet connection is essential in the workplace; most professionals from mechanics to accountants to physicians depend on it to conduct their work, grow their businesses, and collaborate with their colleagues — both locally and globally.

Simply stated, broadband has become *the* enabling technology of modern learning environments. It is the medium through which educators are expanding the very boundaries of the classroom. A broadband Internet connection makes it possible for educators and students to access innovative tools and resources and to collaborate and interact with experts worldwide. It is now a basic requirement of learning environments that have become essential to educators, students, and administrators. Fast, always-on connections make it practical to tap into dynamic online content; to take advantage of evolving collaboration technologies; to provide self-directed and self-paced programs;

to support mobility with anywhere, anytime learning; to enable time-saving and cost-effective professional development opportunities; and to leverage the numerous advantages of content, applications, and services delivered over cloud-based computing systems.

This nearly ubiquitous connectivity is also beginning to transform our schools. More and more states, K-12 districts, and schools are providing students with learning experiences rooted in technologies that prepare them for postsecondary education and to compete in a global economy. Those experiences increasingly depend on a high-speed, broadband connection both at school and at home.

Most K-12 districts in the U.S. now provide their students and teachers with some level of Internet access, but too often the speeds of those connections fall short of what's appropriate for learning in a time where technology pervades all aspects of society. It is difficult to imagine a time when "high-speed Internet access" simply referred to systems that provided a faster connection than a 56 Kbps dial-up service. At those early connection speeds, downloading a good quality MP3 audio file (such as a typical pop song) would take about 15 minutes. Today, the top U.S. providers of broadband services advertise speeds to consumers ranging from just under 3 Mbps to 105 Mbps—which would deliver that same audio file in seconds.[2]

If we want our schools to make the most of rich, online curricular resources, online assessment tools, web-based collaboration systems, digital textbooks, and a host of evolving educational technologies that are quickly becoming essential in a globally competitive world, schools will need more bandwidth. If we truly want to ensure that our students become the innovators who will help the U.S. lead the world, it is imperative that we provide robust broadband access not only to every classroom, but also to every student's and teacher's home and wherever we expect learning to take place.

BROADBAND FOR EDUCATION: A NATIONAL ISSUE

The State Educational Technology Directors Association (SETDA) first looked at broadband in K-12 education in its 2008 report, "High-Speed Access for All Kids: Breaking through Barriers."[3] That paper identified a number of key issues facing the educational community that related to securing access to robust broadband. It made specific recommendations for school connectivity that set the bar for many states and districts.

Since that time, however, the demands on state and district network capacity have grown significantly. Increased use of streaming video in the classroom, for example, is taxing many K-12 networks, as is the burgeoning traffic generated by wirelessly connected laptops, tablet PCs, and smart phones. The requirements of online testing for the Common Core State Standards (CCSS), coming in the 2014-2015 school year, are going to strain network capacity further, as will continued adoption of a new generation of hosted applications and systems available in "the cloud." E-textbooks, many of which are now integrated with web-based rich media and simulations, are adding to the network load and requirements for greater bandwidth.[4]

The National Educational Technology Plan recommends a "comprehensive infrastructure for learning" that includes "broadband access to the Internet and adequate wireless connectivity both in and out of school."

In 2010, the Federal Communications Commission (FCC) foresaw the increased demand for broadband connectivity in K-12 education with the release of its National Broadband Plan.[5] The Plan calls for a dramatic expansion of affordable high-speed connectivity across the country and throughout all aspects of the economy. Among the Plan's K-12-related recommendations for minimum broadband standards in schools, it suggests providing schools more flexibility to purchase lower-cost broadband solutions, and greater efforts to make overall broadband-related expenses more cost-efficient within the E-Rate program. The Plan also recommends providing 1 Gbps connections to community anchor institutions, such as hospitals, libraries, and schools, and sets a bandwidth target threshold for the home of 4 Mbps download and 1 Mbps upload.

Concurrently, the U.S. Department of Education (ED) published the National Educational Technology Plan (NETP) in 2010. Among the recommendations in that publication is a call for a "comprehensive infrastructure for learning" that includes "broadband access to the Internet and adequate wireless connectivity both in and out of school" for all students and teachers.[6]

In fact, later that same year, the Digital Learning Council (co-chaired by Governors Jeb Bush and Bob Wise) in its landmark report, *Digital Learning Now!,* all but endorsed the recommendations included in the federal plans by echoing the call for high-speed broadband Internet access for all public school teachers and students among its ten elements for digital learning.[7]

In 2011, the National Telecommunications & Information Administration (NTIA) unveiled the National Broadband Map, the first publicly available, nationwide, searchable database of broadband Internet availability.[8] Presented in the form of a map of the U.S., this tool allows anyone to log onto the Internet, click on the map, and zero in on an area. The database includes more than 25 million searchable records that

show where broadband service is available, the technology used to provide the service, the maximum advertised speeds, and the names of the service providers. At the time of its release, NTIA highlighted the fact that two-thirds of the nation's schools subscribed to speeds below 25 Mbps, dramatically lower than the 50 to 100 Mbps per 1,000 students recommended in SETDA's 2008 report.[9]

Since 2008 the federal government also has implemented new programs to help provide increased broadband access to unserved and underserved communities most in need. For instance, in 2009, as part of the American Recovery and Reinvestment Act (ARRA), the Broadband Technology Opportunities Program (BTOP) administered by the NTIA, provided $4.7 billion in one-time grant funds to support the deployment of broadband infrastructure, to enhance broadband capacity at public computer centers, and to encourage "sustainable adoption of broadband service." More recently, in November 2011, the FCC approved the creation of the so-called Connect America Fund, which effectively transformed the commission's outdated universal service and inter-carrier compensations systems into a new service aimed at rural broadband users. [10] The goal of the fund is to help seven million rural Americans connect to high-speed Internet and voice by 2016.

Finally, the launch of public-private partnerships is another way that the issue of broadband access for learning has been addressed since 2008. Several broadband services providers, for instance, have developed and launched

discount programs—such as Connect to Compete, Comcast's Internet Essentials, and Century Link's Internet Basics to help provide eligible low-income students with device and broadband access at home. Visit http://setda.org/web/guest/homeinternetaccess for additional details.

While public-private partnerships and federal leadership are helping to draw attention to this issue and to spur the deployment of broadband access to unserved and underserved areas of the country, recent initiatives and programs have in no way resolved the national issue of inadequate and inequitable broadband access for learning in K-12 schools and in homes.

Addressing Slow Connections at School

While the U.S. is moving in the right direction, it's also fair to say that we have a long way to go. The U.S. Department of Education's report, "Educational Technology in Public School Districts", indicated that although 100% of districts were connected to the Internet in the 2008-2009 school year, of the districts with a district network, only 12% had a connection to the ISP with a T3 or DSL3 (digital transmission of data and voice at a speed up to 45 Mbps). Of the schools, with a local area, school-level network, only 4% had a T3 or DSL3 connection. In addition, only 18% of schools on district networks had available wireless connections.[11]

More recently, the Federal Communications Commission's (FCC) 2010 survey of E-Rate funded schools reported that 95% of respondents had some form of terrestrial broadband service to at least one facility, with 2% reporting a satellite connection, and 3% using dial up.[12] Nearly 80% of the respondents reported that their broadband connections were inadequate to meet their current needs. The primary reason: slow connection speeds. More than half of respondents reported connecting at 3 Mbps or greater; only 10% reported speeds of 100 Mbps or greater. Of note, 3 Mbps is actually slower than the FCC's *residential connection* recommendation.

To help tackle the problem of K-12 broadband access, states and districts have employed a variety of strategies. For instance, some states have deployed state broadband networks. These networks provide significant advantages for K-12 schools and districts, including the ability to aggregate purchasing power and enable dynamic routing, which reduces the need for expenditures for so-called commodity Internet services (i.e., commercially available connections to the Internet). A state network can save significant time, personnel resources, and costs as each school or district would otherwise have to conduct a competitive procurement process individually. This approach can provide a base level of connectivity service while allowing for the uniform deployment of state sponsored applications and services. State networks also allow members to purchase additional services and to exercise local control of their level of service. Finally, a state network can provide consistent levels of safety and security over the network to comply with federal and state requirements such as content filtering.[13]

A state network can save significant time, personnel resources, and costs...

Below are several examples of state networks that currently provide cost-effective, robust broadband connections for schools. Included are network plans for expansion based on current levels of use and predictions for increases in demand.

- The Utah Education Network (UEN) is a partnership of public and higher education institutions with local telecommunications providers that connects all of the state's schools to the Internet through a statewide network. A high-capacity backbone connects all of the colleges and universities in the state through middle-mile fiber segments. Ninety percent of the state's K-12 schools connect either directly to that backbone, or indirectly through the colleges and universities. All public colleges and universities connect at 1 Gbps or faster. Most public high schools and middle schools connect at similar speeds. By the end of 2012, the state expects to finish upgrading the Internet connections of 158 elementary and charter schools, 60 public libraries, and 55 Head Start centers to provide 45 Mbps connections. http://uen.org/

- In Maine, a collaboration of several state institutions created NetworkMaine, a consortium made up of the Maine Department of Education, Maine State Library, Maine Office of Information Technology, and the University of Maine System. The network provides broadband connectivity to more than 900 schools and libraries, including many island locations off the coast, at no cost to the school or library. Connection speeds range from a minimum of 10 Mbps to a high of 1 Gbps in some locations. The University of Maine System aims to provide 10 Gbps connectivity to all its universities through an expansion of the Maine Research and Education Network (MaineREN) project by the end of 2012. http://networkmaine.net/about/

Students videoconference with book authors and the district sponsors annual competitions in student film creation and production.

- The Idaho legislature created the Idaho Education Network in 2009 and private sector service providers have delivered Internet bandwidth improvements from 100% to 1,000% more capacity per student, enabling all K-12 students access to online classes offered by Idaho's higher education institutions. http://ien.idaho.gov/
- Network Nebraska provides 212 school districts, 15 intermediate service agencies, 17 higher education institutions, and more than 350,000 K-20 students with communications networks that support Internet2, a statewide synchronous videoconferencing service, and e-learning courses. The state's Educational Service Units (ESUs) purchasing consortium aggregates, shares, and manages common clouds of Internet access across dozens of school districts. For example, 92 districts in the northeast part of the state cooperatively purchase 1,000 Mbps/month of Internet. This allows the ESU managers to manage the peaks and bursts of Internet demand across a region. http://networknebraska.net/
- For additional information on state high speed broadband networks please visit: http://www.setda.org/web/guest/statenetworks

In addition, leading school districts across the country are working to upgrade their broadband access to better meet the demands of teachers and students.

- Several California districts offer examples of the bandwidth speeds needed to make the most of media-rich learning options for students through the state-funded program, the K-12 High Speed Network, which supports aggregation points in each of California's 58 counties, mostly located at County Offices of Education (COE). Corcoran Joint Unified School District in Kings County, California—with its agricultural-based economy and high-minority populations—has deployed a 1-to-1 program. Kings County Office of Education connects via a 1 Gbps circuit to the all-education California Research and Education Network (CalREN). Corcoran's eight schools' connections range from a 100 Mbps to a 1 Gbps connection to the COE. In addition, California's Elk Grove schools are connected from 10 Mbps to 1 Gbps to the district office, which in turn connects to the Sacramento County Office of Education. The Sacramento COE is served by a 10 Gbps fiber connection to CalREN. In addition to using their bandwidth to permit students to videoconference with book authors, they also sponsor annual competitions in student film creation and production to support the attainment of 21st century skills.http://k12hsn.org/, http://cenic.org/calren/
- In 2010, Arizona's Florence Unified School District boosted its existing 45 Mbps DS-3 connection to a 100 Mbps Ethernet connection. To get to that speed, the district installed an optical fiber connection in one of its suburban

schools. It utilized a licensed wireless wide area network (WAN) to connect all of its buildings to this connection. But the district quickly found that speed to be insufficient, and a month later increased it to 1 Gbps. Florence Unified reports that the district is now able to provide students and teachers with ample bandwidth to access all of the necessary digital content. The results of the access: increased assessment scores and improved teaching practices, the district reports, which would not have been possible without its governing board and administration's commitment to network infrastructure. http://fusdaz.org/

The above states and districts provide examples of how leadership at the state and district level can enable the management and upgrades needed to achieve adequate bandwidth for K-12 learning environments.

Making Out-of-School Access a Priority for Learning

Home access to broadband is arguably as important to the overall quality of the learning experience as access at school—and it is a key strategy in extending learning time. Connected students are able to get homework help and submit their assignments online. They can use the connection to collaborate with fellow students after school, access research materials, develop multimedia projects, and use advanced features of digital textbooks. Without broadband in the home, 1-to-1 programs can lose a great deal of their effectiveness. Perhaps the Digital Textbook Collaborative said it best in its 2012 report, "Digital Textbook Playbook," "While schools must be connected in order to create a successful digital learning environment, digital learning cannot only happen at school. To accomplish truly ubiquitous learning, students must be able to connect outside the school walls."[14]

In the National Broadband Plan, home access to a high-speed Internet connection is described as "critical to maximizing utilization," and there's no doubt that Internet use is on the rise. Researchers at the Pew Internet and American Life Project found that between 2000 and 2011 the percentage of American adults with access to the Internet from home via a broadband connection rose from fewer than 5% to 62%.[15] However, adoption rates have leveled off since 2009 at roughly 65% according to the TechNet report "Broadband Adoption in 2012".[16] This plateau in home broadband adoption reflects, in part, a percentage of the population that is older, less educated, and in general less inclined to adopt information technology. But that group also includes people who simply cannot afford a broadband connection.

To accomplish truly ubiquitous learning, students must be able to connect outside the school walls.

Schools and districts are also recognizing the need for access outside of school and in some cases are working to provide access before and after school and off campus. For example, Louisiana's Northwood High School, a rural school of about 800 students in Rapides Parish School District in Alexandria redesigned its curriculum and implemented a 1-to-1 netbook program with a variety of online resources, including advanced placement opportunities, distance learning classes, and subscription-based services. A cornerstone of the new plan was the establishment of on- and off-campus, wireless hotspots that allowed students to access Internet resources before, during, and after school. The off-campus hotspots were installed at community centers and on the nearby Native American reservation.[17] In Missouri, after a tornado destroyed five schools in the Joplin Schools district in May 2011, the district decided to fast-forward its planned technology upgrades.[18] Under the auspices of its 21st Century Vision team, and with the help of a $1 million donation from the United Arab Emirates, the district implemented a 1-to-1 initiative for all 2,200 high school students, rebuilt and upgraded its network to provide 100 Mbps bandwidth to the high schools, as well as eight new hotspots outside of class for students to use after school hours.

TRENDS DRIVING THE NEED FOR MORE BROADBAND IN EDUCATION

In a 2012 market study, the Telecommunications Industry Association (TIA) found that smartphones, tablets, cloud services, and digital video are already "placing unprecedented demands on the broadband network."[19] TIA concluded that "global Internet traffic will quadruple by 2015, and in the next five years, mobile broadband usage will be 35 times what it is now."

For decades, technology has been slowly and steadily integrated into K-12 education, with computers, software, and an ever expanding range of Internet-ready devices designed to provide easy access to rich digital and online curricular resources. Current trends make it clear, however, that the pace of change is rapidly accelerating and that broadband has become a core-enabling infrastructure for learning and modern school operations. This section takes a brief look at some of the current trends in education with the understanding that while they are examined in isolation in this paper, in fact many school districts are incorporating a variety of these trends to increase efficiency and provide students with learning experiences rooted in technologies that prepare them to compete in a global economy.

Shift to Digital and Online Tools and Services

As more and more educators turn to online resources and capabilities, the strain on district networks increases. The growing popularity of online learning tools and web-based content (including rich media such as videos), the arrival of interactive digital textbooks, the advent of online assessments, and the increasing dependence on the web for professional development all contribute to the rapidly increasing flow of digital traffic demanding more bandwidth.

Video Streaming

One of the most bandwidth intensive activities is streaming education content via videos. Since SETDA's 2008 report, the amount of video that is being streamed to the classroom over the Internet has increased dramatically. In their 2010 teacher survey, PBS and Grunwald Associates found that the percentage of teachers reporting that they stream or download video content in the classroom increased from 55% in 2007 to 76% in 2010.[20] Most of those teachers (78%) also reported bandwidth associated problems when they streamed video—skipping, pausing, or constant buffering—indicating, as the report states, that their "computing devices or technology infrastructure, or both, do not yet have the capacity to handle teachers' increasingly Internet-dependent instructional activity."

Video files are much bigger than text, graphics, or audio files, and therefore take more bandwidth on the network. To get a sense of how much bandwidth is required for streaming video to the classroom, we looked to the providers of consumer services, which is where such technologies tend to be proven before they find their way into education. According to consumer technologies manufacturer LG Electronics, one provider of televisions, "instant streaming" of a Netflix movie to a network-ready device requires a

minimum bandwidth of 1.5 Mbps to play an uninterrupted video. A network with at least 3 Mbps or higher available bandwidth will provide the best video and audio quality during playback for standard definition content, LG says on its website.[21] For High Definition (HD) content playback, 5 Mbps or higher is required.

Cable television and Internet services provider Comcast offers a chart on its website showing examples of download speeds for different video quality levels, from a 4 GB HD movie (5 minutes at 105 Mbps; 1.5 hours at 6 Mbps) to a standard definition TV show (20 seconds at 105 Mbps; 7 minutes at 6 Mbps).[22] These example broadband requirements and download speeds are for single consumers; however; they provide important data for technology specialists planning for broadband demand increases. For example, if six classrooms in the same building are all showing HD movies, leaders must plan for adequate broadband coverage for all six classrooms to stream a video concurrently.

Downloading Content

Traditionally, one of the most basic Internet-connected activities in which students and teachers engage is downloading information from webpages. Downloading content may include text, presentation files, videos, music, or books. Connection speeds greatly impact the user experience when downloading content. Assuming for this example that there is only one user of the network connection, as you might find in a home, and no other network traffic, downloading a 1 MB digital book at 200 Kbps takes about 40 seconds; increase the network capacity to at least 3 Mbps and the same textbook can be downloaded in just over 1 second. Assuming there is no other traffic, networks that have met the National Broadband Plan's suggested home speed threshold of a minimum download speed of 4 Mbps could download a 4 MB song file in just over 5 seconds and a 6 GB movie file in just over 2 hours. On a 10 Mbps connection, that book, song, and movie could be downloaded in 0.3 seconds, 1.3 seconds, and 33 minutes, respectively.[23] Of course, in schools, leaders must consider not only the connection speed but also the number of concurrent users.

Florida's Clearwater High Replaces Paper Textbooks with E-Textbook

In 2011, Clearwater High School in Pinellas County, Florida handed out Amazon's Kindle e-book readers, instead of textbooks to its students. More than 2,000 students received the devices loaded with e-textbooks tailored to their individual class schedules. The devices were also bundled with more than 100 novels, and provided access via the district network to local newspapers. Another feature allowed students to go online and check their grades, get assignments, and even take tests with the devices. The school expected the "Kindalization" of Clearwater High to boost reading and improve study habits.

That same year, the Florida Board of Education rolled out a proposal to adopt digital-only textbooks by the 2015-16 school year and spend at least 50% of their textbook budget on digital materials by that time.
http://clearwaterhighschool.com/

Digital Textbooks

E-textbooks and other digital educational content, including a range of open educational resources, are fast becoming significant factors in the broadband-in-K-12 equation. In the FCC's 2010 survey of E-Rate funded schools cited earlier, 56% of respondents expected to implement or expand their usage of digital textbooks in the next two to three years.[24] Policymakers at all levels are seeing the power of digital content to engage students and encourage deeper learning, and are changing policies to encourage more and greater use of digital content. At the state level, policymakers in

approximately a third of the states have changed the definition of textbooks to include digital content or have otherwise made the purchase and distribution of instructional materials more flexible and inclusive of digital resources. At the federal level, the NETP has numerous references to digital content and open educational resources, as does the FCC's National Broadband Plan.[25] [26]

In fact, in February 2012, U.S. Secretary of Education Arne Duncan and Federal Communications Commission Chairman Julius Genachowski challenged schools and companies to get digital textbooks in students' hands within five years.[27] That same month, the Digital Textbook Collaborative released a 67-page report ("Digital Textbook Playbook") with the aim of helping K-12 school educators "plan for the transition to a rich, interactive, and personalized digital learning environment. Central to the report is the idea that schools need to provide "robust and persistent connectivity to the digital content." [28]

E-textbooks contribute to the demand for bandwidth because they incorporate online content and services, including online tutorials, multimedia, simulations, social tools, and a wide range of web-based educational resources. In addition, in some cases, students can highlight resources and build a digital notebook. This new e-textbook environment effectively packs more information into textbooks and other learning vehicles, and increases the demand for broadband access.

The new assessment systems will almost certainly increase bandwidth traffic for all K-12 districts.

Online Assessment

States have led the way in the administration of online assessments. Thirty-three states currently offer some form of online testing. Oregon and Virginia initiated the charge in 2001, followed by

Texas in 2002. Delaware, Hawaii, Nebraska, South Dakota, and Washington launched statewide online testing during the 2010-2011 school year.

States implementing online testing require schools to offer a "fast" Internet connection, but have tended to be circumspect in providing more detailed guidelines on what "fast" means. The reason for this may be the great variability on the number of students being tested as well as the nature of the assessment itself. More students being tested simultaneously increases Internet bandwidth demands. Exams that require a great deal of interactivity will also require greater capacity. [29]

Regardless of the bandwidth and connectivity theoretically available, states recommend that schools test their capacity for the particular exams and number of students that will be assessed. The online assessment system should be responsive and not cause additional stressors to the student.

On the national level, 42 states, the District of Columbia, and the Virgin Islands have formally adopted the state-led Common Core State Standards (CCSS), developed by the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for Best Practices (NGA Center), and are in various stages of implementing them in their state education systems. [30]

ED has allotted $350 million from the Race to the Top [31] competition to fund five state assessment consortia based on the Common Core Standards: the Partnership for the Assessment of Readiness for College and Careers (PARCC) and the SMARTER Balanced Assessment Consortium (SBAC), both of which are developing CCSS-aligned assessments in English language arts/literacy and mathematics; Dynamic Learning Maps (DLM), an alternative assessment system for students with significant cognitive disabilities that maps a student's learning throughout the year; the National Center and State Collaborative (NCSC), a multi-state comprehensive assessment system for students with significant cognitive disabilities; and Assessment Services Supporting ELs through Technology Systems (ASSETS), a state-led consortium aiming to provide innovative and comprehensive assessment tools for English learners.

SETDA believes that online administration of assessments is the key to the success of the next generation of CCSS-aligned assessment systems. Online administration will make it possible for the first time in public education to realize the economies of scale and cost savings necessary to begin to deploy a truly transformative student assessment system.

The new assessment systems developed by the consortia will be implemented starting with the 2014-15 school year, and the assessments will be delivered online. The systems will almost certainly increase bandwidth traffic for all K-12 districts. PARCC and SBAC plan to release final guidance related to bandwidth requirements for the new online assessments by fall 2013.

In addition, states are encouraging schools and districts to conduct ongoing, online formative assessments for learning to be used to inform instruction throughout the learning process. This ongoing formative assessment process requires frequent testing and evaluation to help teachers plan for instruction based upon individual student needs and also increased bandwidth demands.

Metropolitan Nashville Upgrades Broadband and Online Assessment

In 2006, Metropolitan Nashville Public Schools (MNPS), an urban district in the Middle Tennessee area serving 79,000 PK-12 students, began deploying a broadband network to facilitate online testing, improve student data utilization, and position the district for future innovations.

MNPS implemented the connectivity upgrade through managed network services over several years based on demand and funding availability. With its infrastructure upgrade, the district's current deployment leverages approximately 196 Mbps per student. The district reports a 150% increase in broadband service consumption over the past two years, a trend MNPS expects to continue and slightly increase over the next five years. MNPS developed a partnership with ENA, its service provider, and a plan of growth utilizing Metro Ethernet based carrier services for the next five years.

Among other things, the increased bandwidth has made it possible for the district's educators to utilize online testing tools that provide real-time data to measure growth and accurately predict student proficiency on high-stakes exams, and to develop appropriate interventions.
http://mnps.org/site234.aspx

Online Learning for Students and Teachers

Online learning continues to expand the demand for broadband in K-12. In a report published by the International Association for K-12 Online Learning (iNACOL), more than 1.5 million K-12 students were engaged in some form of online learning opportunities that supplement traditional classroom-based courses or blended learning programs that combine traditional classroom-based learning with online learning assets during the 2009-2010 school year.[32] At the end of 2010, supplemental or full-time online learning programs were available in at least 48 of 50 states, plus the District of Columbia.

Alabama Promotes Distance Learning

Alabama's Connecting Classrooms, Educators, and Students Statewide (ACCESS) distance learning program serves students in grades 6 to 12 statewide by delivering instruction via the web and interactive videoconferencing.

In 2011, ACCESS provided 39,129 student enrollments in courses needed to meet graduation requirements and 5,123 additional enrollments in non-credit remediation modules for the state high school graduation exam. In 2007, the average freshman graduation rate was 67%, up from 62% in 2002. Ongoing evaluation indicates continued positive success rates. These results were only possible because Alabama supported the program with the infrastructure to provide adequate bandwidth at all high schools.
http://accessdl.state.al.us/

Online courses also provide access to advanced placement courses in areas where they are not available locally. They offer opportunities for credit recovery, allowing students to stay on target for graduation.

Broadband is fast becoming essential to educators who want to make the most of the available online resources for professional development.

In the 2011 survey conducted by Project Tomorrow for its annual Speak Up National Research Project, Project Tomorrow researchers reported that about a third of responding middle school and high school students said they were currently taking at least one online class.[33] The Speak Up survey, which was facilitated through schools and districts that voluntarily registered to participate (not a random sampling), indicated that 46% of students in grades 6 to 12 who had not taken an online class said they would like to do so—that's an increase of 95% in interest of middle school students in online learning since 2007. The survey also found that more than 40% of students now designate online classes as an "essential component of their learning experience." Obviously, with more students engaged in online learning, and at this growth rate, schools will need to increase their bandwidth capability concomitantly.

Educators are not strangers to online learning either. Broadband is fast becoming essential to educators who want to make the most of the available online resources for professional development, including online courses, education repositories, professional learning communities, and communities of practice. Online professional development trends seem to be the preference for teachers. In a recent Speak Up survey, researchers found that 52% of teacher participants indicated that they have taken an online class for their own professional development, which was a 100% increase over the previous year. Another 18% indicated that they have taken a blended online professional development class. Thirty percent

say that a fully online class is their preferred approach for professional development now; in 2006 only 7% of teachers said they preferred online professional development. Almost two-thirds of district administrators and just over half of school site administrators surveyed say they have participated in an online professional development class.

Access to online professional development resources is particularly important to rural areas, where access to effective modes of professional development is often limited. These resources are essential tools for educators seeking certification and recertification, because they provide access to courses not available locally, and they permit busy teachers to work with one another anytime, anywhere. According to ED's "Educational Technology in U.S. Public Schools: Fall 2008" report, 59% of schools offered online professional development, provided by the school or district, through their district networks.[34] As teachers opt to participate in online professional development courses and online communities of practice they also impact the amount of broadband required. Many online courses include video streaming and videoconferencing; online communities of practice often include a multitude of resources available for download and online collaboration tools.

Texas Expands Online Professional Development Offerings

Launched in 2011, Project Share is a collection of Web 2.0 tools and applications that provides high-quality professional development in an interactive and engaging learning environment. Project Share leverages existing and new professional development resources for K-12 teachers across the state and builds professional learning communities where educators can collaborate and participate in online learning opportunities by taking online courses, communicating with experts, accessing dynamic digital content, and providing each other with feedback. Partners of the program include The New York Times Knowledge Network, McDonald Observatory StarDate, PBS Digital Learning Library, and Texas PBS. As of the April 2011, over 882,000 Texas K-12 educators and students had established accounts to access online courses, content repositories, Web 2.0 tools, and secure, private connections with other online learners.
http://projectsharetexas.org/

Device Explosion

It is no exaggeration to characterize the increasing presence of a range of computing devices in K-12 environments as an "explosion." Laptops, netbooks, the new species of tablets, and an incredibly powerful new generation of handhelds are all adding to the strain on district networks. This device explosion is driven by two key factors. The first is a desire for K-12 students to have the same capabilities that college students and virtually all workers have—their own device. This has created a growth of 1-to-1 programs, including those that take advantage of student-owned devices, also known as Bring Your Own Device, or BYOD. A second is the consumer world where there has been an unprecedented growth of tablets and smartphones. As families and students become more dependent upon and comfortable with these devices, they begin to imagine the power they can bring to education.

Henrico's Long-Running Laptop Program Relies on High-Speed Connection

Virginia's Henrico County Public Schools maintains one of the largest and longest running 1-to-1 laptop initiatives in the United States. Currently, of the 49,000 students in Henrico's schools, 31,000 have their own, district-provided laptops. Teachers and students use their laptops daily to access digital curricula stored on Henrico's data center, videoconference with experts around the world, collaborate online via the district's own content management system, and take online courses and conduct online research.

In the spring of 2011, the district upgraded from a 300 Mbps Internet connection to a 500 Mbps connection. The district is currently coordinating plans to establish a 1 Gbps connection in the spring of 2012 to accommodate an increase in demand for broadband access. Each of the district's 22 secondary schools now has a 100 Mbps connection to Henrico's cloud, and from the cloud to their data center via a 1 Gbps line.

High Access and 1-to-1 Programs

Since 2008, interest in programs that provide individual students with their own devices has continued to grow throughout the country. The states have led this trend in multiple ways including implementing 1-to-1 programs. Since 2001, for example, the Maine Learning Technology Initiative (MLTI) has provided 1-to-1 laptop computers to all middle school students, teachers, and administrators, and 45% of high school students, as well as providing professional development for teachers. Research has found an increase in student achievement and engagement, and an increase in teacher use of the technology tools.[35] North Carolina's IMPACT program is another example. The research-based 1-to-1 program supports technology-rich learning environments in which students have shown an increase in math performance when compared to a control group.[36]

The State of Idaho is investing $13 million each year in its Students Come First program, which focuses on "advanced classroom technology, including hardware and necessary professional development."[37] Some states are designing district grant program competitions focused on high access and 1-to-1 programs. The Rhode Island Department of Elementary and Secondary Education, for example, is currently awarding grants to support schools that "create a technology-rich learning environment that fundamentally rethinks and restructures teaching and learning" with a range of technology-based programs including 1-to-1 computing.

Bring Your Own

New economic realities are changing policies and attitudes about students bringing their own technology tools to school. The new "Bring Your Own" Device/Technology (BYOD/BYOT) trend is becoming more common in school districts as an increasing number are not only allowing students to bring smart phones and laptops they own to school, but they are encouraging it. These BYOD initiatives permit students to access the school's wireless network, therefore increasing demand.

Bring Your Own at Forsyth County Schools

Georgia's Forsyth County Schools are exploring what students and teachers can do when they are allowed to bring their own technology tools—laptops, netbooks, iPads, smartphones—to school through an initiative called Bring Your Own Technology (BYOT). One hundred percent of the schools in this district are currently involved in the program. On average, 35% of classrooms in each school are fully engaged in using BYOT on a regular basis. To support the program, the district upgraded its broadband connection during the summer of 2011 from 550 Mbps to a total of 1.25 Gbps. To provide system redundancy, the district aggregated connections from three different providers, and was able to increase bandwidth for essentially the same cost. Most schools in the district now have dual 1 Gbps connections to the districtwide network. The district maintains two local area networks accessible to staff and students. http://www.forsyth.k12.ga.us/site/Default.aspx?PageID=1526

Tablets and Smartphones

Perhaps the most significant change in the device landscape since our 2008 report is the arrival of the tablet computer. Not to be confused with what industry analysts have called "traditional tablets" (laptops with swiveling and/or detachable screens that supported a stylus-input technology known as digital ink), the new form pioneered by Apple's iPad created a new device category, the tablet. Multiple vendors now provide tablet devices to schools. By 2011, approximately 600 K-12 districts had begun providing their students with tablets.[38]

Another trend underscoring the need for broadband in K-12 is the widespread use of handheld and smartphone devices. In the FCC's 2010 survey of E-Rate funded schools cited earlier, 45% of respondents expected to implement or expand their usage of handheld devices for educational purposes. In the latest Speak Up survey, 55% of high school students and 45% of middle school students report that they access the Internet when at home through a 3 G/4 G or wireless enabled mobile device. As ubiquitous as smartphones may be, however, they're not yet the platform for everything a student might need to do online (such as access an e-textbook or to take an online test). It's also worth acknowledging that it can be much more costly to access the Internet with a smart phone over a 3 G/4 G network than via broadband access and therefore most schools and districts are focused on providing broadband access instead of 3 G/4 G access.

Internet-Enabled Communication Services

VoIP

Voice over IP, better known as VoIP, has also found its way into the K-12 tech toolbox.[39] School districts are using VoIP solutions to place voice calls and transport voice traffic over the data network, enabling schools to make cloud-based voice services a critical part of their technology infrastructure. School administrators and technology leaders are discovering how hosted VoIP communication lowers total cost of ownership (TCO) while improving productivity and security for schools. In addition to enterprise-wide VoIP solutions, teachers are integrating tools such as Skype and Google Talk for interaction as part of daily classroom instruction.

Although technology for making telephone calls over the Internet and schoolwide area networks is budget friendly, the calls add to network traffic, and thus, the need for greater bandwidth. That demand varies with usage. A standard call over Skype, for example, requires a minimum of 30 Kbps/30 Kbps (download/upload capacity), but the company recommends 100 Kbps/100 Kbps.[40]

Videoconferencing

Videoconferencing is real-time visual and audio communication using a computer, a video camera or webcam, and a network connection, and is becoming increasingly popular in K-12 classrooms. Sometimes called classroom conferencing, this service supports virtual face-to-face collaboration providing access to experts around the world to geographically disparate students and teachers. States and districts also use videoconferencing to provide professional development and peer coaching sessions for teachers.

Popular equipment from Cisco, Polycom, and Lifesize enables a full classroom to experience rich videoconferencing, and newer desktop-based solutions from a variety of competitors allow flexibility for students and teachers to communicate from their desktops or tablets.

Broadband Connects Islands in Maine

In 2009, a group of K-12 educators working in schools located on the five islands that make up the Maine town of Cranberry Isles needed to build a network of support for both their teachers and students. Islesford School, Monhegan School, Matinicus School, Isle Au Haut School, and Cliff School support K-8 students in one-room schoolhouses often with only one student per grade level. Since island hopping is costly, time consuming, and actually dangerous in the winter, collaboration had to be supported by technology. The schools each have at least 50 Mbps access and participate in Maine's 1-to-1 initiative.

Under the auspices of the Outer Island Teaching and Learning Collaboration (TLC), teachers created a virtual classroom community where teachers and students had access to a rich and supportive inter-island peer network in which they videoconference daily. The Outer Islands TLC now serves as the "one-room school of the five islands." The schools team up for a writing lesson and the students use Skype and cloud computing applications on partner assignments. Teachers take turns teaching lessons and preparing assessments. http://outerislandstlc.org/

Online Collaboration Tools

Internet connectivity in schools has opened the floodgates of online collaboration. Online collaboration tools have become cornerstone features of K-12-focused learning management systems (LMSs) and Internet-based learning applications. Blackboard, Moodle, cloud computing applications, and others offer everything from "interactive learning experiences" to virtual classrooms as part of their basic feature set. Wikis, both as features of larger systems, and as stand-alone products, provide online environments for collaborative document editing.

In addition, a small but growing number of schools integrate popular social networks, such as Facebook and Twitter, into their classes.

This increasingly essential educational activity can be seriously degraded by a slow Internet connection. Being able to share information in real time, to edit work, and add resources, provides additional opportunities for feedback and collaboration, both during class and outside school. Students don't have to wait days to meet with a group and/or for the teacher to grade a stack of papers; they receive instant feedback.

Pennsylvania District Integrates Technology into the Teaching-Learning Process

Starting with the two Upper Darby middle schools, the densely populated and urbanized Pennsylvania district provided a laptop for each of the schools' 215 teachers, and supported them with a full-time instructional technology coach, which both schools shared. Each school also received two laptop carts earmarked for the eighth grade social studies programs. As part of the program, the district increased their WAN to 1 Gbps.

Because of the high-speed Internet, the eighth grade students have been able to effectively access the online content necessary to research the history of the Alexander Hamilton/Thomas Jefferson debates and develop a position statement via a wiki. Nor would they have been able to participate in a videoconferencing session with a university debate team without the high-speed connection. The students eventually created video podcasts (vodcasts) of their debates modeled on the Hamilton/Jefferson debates. The teacher also posted lessons online and published student projects. http://www.upperdarbysd.org/

Today, social networks are also finding their way into a growing number of classrooms. In a 2010 report from *The Journal of Online Learning and Teaching* researchers referenced the term "educational networking" to define the use of social networking technologies for educational purposes.[41] In Palo Alto Unified School District in California's Silicon Valley, for example, teachers and students use Facebook as a primary communications medium. The district has set up a main page for both Palo Alto High School and Gunn High School, as well as pages for the schools' libraries, choirs, and tutoring services. Teachers also create Facebook pages for individual classes to facilitate collaboration on assignments.

The Pew Internet and American Life Project recently reported that 80% of teenagers who are online now participate in social networking sites. Students turn to social networks to help them evaluate information, to establish "warning signals" about what's going on in the world, and to get help with their studies from other students. Students who participate in social networking also appear to be more inclined to collaborate with peers. To these students, decision-making is no longer a solitary event, and learning is a social experience.[42]

It's not just the students who use social networking. A 2009 survey of K-12 educators ("A Survey of K-12 Educators on Social Networking and Content-Sharing Tools") co-sponsored by edWeb.net and MMS Education found that 61% of educators had joined a social network.[43]

Specialized education-focused social networks are also emerging. Edmodo, for example, provides a social platform for students and teachers. Classroom 2.0 is a growing social network of educators and "those interested in Web 2.0, social media, and participative technologies in the classroom." EdWeb.net bills itself as "a professional social network for the education community." Some new tools are also emerging for educators who want to create their own social networks; Ning, for example, was used to create Classroom 2.0. Many schools also leverage social media resources such as those available on YouTube, Flickr, Diigo, and Pinterest.

Cloud Computing

Underlying virtually all of these trends is "the cloud," an umbrella term for a group of technologies that provide and manage data storage, application deployment, even computing from remote servers. This computing-as-a-service model, which moves data and applications to offsite servers and delivers them on demand to end-user devices (PCs, smartphones, etc.) via the Internet, is taking the business community

Lawrence Township Expands Its Learning Spaces

In 2010, Lawrence Township Public Schools (LTPS), a suburban district in Mercer County, New Jersey, received grant funds from the state's TALENT21 (Teaching and Learning with Essential New Technologies in the 21st Century) program to establish a "reliable and robust wireless network" and a 1-to-1 wireless mobile computing environment. LTPS focused to give teachers and administrators the skills they needed to prepare the students for life after high school in a technology-driven world.

Teachers were instructed on how to integrate multiple online tools, such as Diigo, Google Earth, Jing, and wikis into the curriculum. Administrators were trained to communicate with parents, community members, and students through social networks, such as Twitter, Facebook, and blogs.

Students in the district's intermediate and middle school were provided with netbooks they could use at school and at home. In the two schools, access points were upgraded from "G" to "N," increasing the accessible wireless bandwidth to the classrooms from 54 Mbps to 144 Mbps. The switches that provide the bandwidth to the access points as well as between buildings were upgraded, enabling them to provide 1 GB connections to the access points and 10 GB connections between schools. This provided significant improvement from the original 1 GB switch. While the current provider at the intermediate school does not have adequate bandwidth, the district is currently running their its own fiber that will enable Lawrence Township to provide a 10 GB connection. This will decrease the carrier costs while allowing the technology to meet the current demands of the growing 1-to-1 initiative. http://ltps.org/

by storm. Districts are turning to the cloud to save money, increase accessibility, and enhance security. Cloud-based services, such as GoogleApps, are becoming essential tools in many K-12 districts. Making the most of remotely hosted services and storage requires a high-speed Internet connection.

Illinois's IlliniCloud, for example, is a district-owned, vendor-neutral, standards-based community cloud that provides state-of-the-art computing resources to K-12 schools throughout the state. The IlliniCloud supplies participating school districts with a secure and reliable means of hosting a variety of Illinois K-12 applications in an infrastructure as a service (IaaS) environment. Participating school districts are given access to managed applications within that infrastructure, including student information systems, and curriculum and instructional applications offered in a software-as-a-service (SaaS) model. In addition, the IlliniCloud hosts disaster recovery options for local software applications of the participating school districts, as well as applications hosted within the IlliniCloud. http://illinicloud.org/

Sample Broadband Requirements (Download Only) for Various Activities

The chart below identifies the typical broadband speeds required for the seamless integration of activities that support student learning experiences. In this chart the speeds are indicated per-user based on the trends indicated in the above section.

Activity	Recommended Download speeds
Email and Web Browsing	500 Kbps[44]
Download a 1 MB digital book in 5.3 seconds	1.5 Mbps[45]
Online Learning	250 Kbps[46]
HD-quality Video Streaming	4 Mbps[47]
Skype Group-Video Session, 7+ people	8 Mbps[48]
Download a 6144 MB Movie in 8 minutes	100 Mbps[49]
Current Generation Multiple Choice Assessments	64 Kbps/student[50]

* Averages are indicated for single users

A FRAMEWORK FOR ASSESSING SCHOOL BANDWIDTH REQUIREMENTS

Just as there is no one-size-fits-all model for digital learning in schools, actual bandwidth needs will vary. Actual throughput depends on such variables as the number of concurrent network users, usage patterns, types of content, and traffic on the backbone. In addition to student use, schools must consider bandwidth for data systems operations, administration and reporting, other back-office school operations needs, and teacher professional development opportunities. Most importantly, schools must plan for meaningful learning experiences rooted in technologies to best prepare students for college and to compete in a global economy. Broadband access should never be a factor when teachers or students are planning for educational activities.

One useful metric is *bandwidth-per-student/teacher*, which directly correlates with the quality of a student's online experience. It defines a framework for assessing bandwidth requirements based on what the users, both students and teachers, truly need to engage in the range of activities that necessitate an Internet connection. Leaders must consider the number of concurrent and peak connection times in schools when evaluating their school's broadband needs.

"It's challenging to predict needs," says Henrico County, Virginia's Director of Technology, Lloyd Brown. "But it's critical for schools to continually review and monitor network usage to best meet the needs of the teachers and students."

Broadband needs vary from school to school, of course, but a common evolutionary path has emerged since our 2008 report toward what we term "technology-rich learning environments." [51] [52]

A technology-rich learning environment is an aligned and synergistic education system that:

- Provides equitable access to quality learning tools, technologies, and resources such as: laptops, tablets, projectors, video cameras, interactive whiteboards, interactive response systems, education portals, learning management systems, digital content, online assessments, and/or collaborative tools
- Enables students to learn in relevant, real-world contexts through project-based or other applied work
- Provides avenues for group, and individual learning
- Personalizes and blends the educational experience through face-to-face and online opportunities, and frequent feedback on performance
- Supports online professional learning communities that enable educators to collaborate, share best practices, integrate new skills into classroom practice, and assess their effectiveness.

While many schools are still on the path toward building technology-rich learning environments for their students and faculty, policymakers and school leaders need to understand the likely trajectory of K-12 education and plan for adequate access.

The example below illustrates how the broadband needs of schools are fluid and may develop over time—from basic connectivity for supplemental enrichment, to emerging reliance on online educational tools and resources, to a technology-rich learning environment.

Basic Connectivity for Supplemental Enrichment

A high school might start integrating technology into its curriculum by connecting a group of desktop machines in a standard computer lab to the Internet. In this setting, the students are scheduled to visit a central lab to access locally-run software applications, go online to conduct research for term papers, and compose occasional papers and presentations. Faculty and staff might use the network primarily for email and to post newsletter updates and announcements to the school's website and to track attendance records. A ***10 Kbps per student/staff broadband connection*** provides these students and teachers with enough capacity to avoid slow downloads and frustrating delays while engaging in these low-bandwidth activities.

Emerging Reliance on Online Educational Tools and Resources

Over time, the school expands its use of Internet-based educational tools and technologies in numerous ways. It implements a partial 1-to-1 laptop program (9th and 10th grades only) and encourages its students to use their devices to access the web for more dynamic content, collaborate with other students, download videos, and receive and post assignments on the school's learning management system. Teachers begin adding some online assessment activities to their lessons, and administrators start to use web-enhanced office management software. To support the increased network traffic generated by these activities, the school upgrades its network to a ***50 Kbps per student/staff broadband connection*** to best meet the needs of teachers and students.

Transformation to a Technology-Rich Learning Environment

Once Internet-based educational technologies and practices have been integrated into the curriculum, teachers and students naturally begin exploiting the full potential of their connectedness. Students actively use their laptops in class to access rich, multimedia-enhanced educational content from the Internet. They post their content (including audio and video podcasts) to school learning management systems, access their e-textbooks and get their assignments online, and collaborate daily across the network with other students via wikis and other Internet-based applications. Teachers regularly download streaming media to the classroom and take their students on virtual field trips to interact with subject area experts. Classes use videoconferencing systems to interact with other classes on campus, as well as students and content experts around the world. Formative and summative assessments are conducted online for all students. The school expands its curriculum to include online courses, which students access at school, from home, and through various WiFi hotspots in the community. Teachers actively participate in online professional learning communities to share lessons and to participate in professional development. To support these contemporary classroom activities, the school upgrades its network to provide a ***minimum of 100 Kbps per student/staff broadband connection***. The reliance on dozens of bandwidth intensive activities, coupled with large numbers of concurrent users, requires this jump in bandwidth.

Moving Forward

As federal, state, district, and school leaders plan for the modern learning environment, they should make certain that those plans provide enough bandwidth so that availability never becomes a concern of the educator. In other words, if the question, "Do we have enough bandwidth for that?" never comes up, then teachers and students can simply focus on their schoolwork. Perhaps even more importantly, a seamless relationship between educational tools and Internet resources provides opportunities for innovation.

Leaders should expect the next generation of educational tools and technologies to create even greater demands on the network in the future. If recent trends are any indication, bandwidth requirements are all but destined to increase. "The cloud" wasn't even part of the conversation a few short years ago. Also, consider how quickly—and for the most part, unexpectedly—video streaming became an essential means of delivering educational content to the classroom, and how educators are beginning to incorporate online collaboration into their lessons.

CONCLUSION & RECOMMENDATIONS

The increasing demands of preparing all students for college and careers will require additional bandwidth in many, if not most, K-12 districts in this country over the next few years. A school's bandwidth increasingly determines which online content, applications, and functionality students and educators will be able to use effectively in the classroom, and without an upgrade many will be left behind. Moreover, out-of-school access to digital learning resources via broadband must be addressed if 24/7 learning environments are to become a reality for students.

Given current trends and the real-world experiences of states and leading districts, SETDA offers four recommendations for K-12 policymakers and school leaders committed to charting a course for the future of K-12 education enabled by broadband:

Recommendation 1: Move to Address K-12 Broadband Infrastructure Needs

Broadband is *the* enabling technology of modern learning environments, and broadband concerns should never be a factor when teachers or students are planning for educational activities. Unless we swiftly and systematically move to address the impending bandwidth dearth facing schools nationwide we will find it to be the limiting factor in school reform and improvement.

To reach the goal of sufficient broadband access for enhanced K-12 teaching and learning and improved school operations as outlined in this report, SETDA recommends that schools and districts meet the following *minimum* bandwidth targets between now and the 2017-18 school year:

Broadband Access for Teaching, Learning and School Operations	2014-15 School Year Target	2017-18 School Year Target
An external Internet connection to the Internet Service Provider (ISP)	At least 100 Mbps per 1,000 students/staff	At least 1 Gbps per 1,000 students/staff
Internal wide area network (WAN) connections from the district to each school and among schools within the district	At least 1 Gbps per 1,000 students/staff	At least 10 Gbps per 1,000 students/staff

Recommendation 2: Ensure Universal Broadband Access

Home access to broadband is arguably as important to the overall quality of the learning experience as access at school and is key to extending learning time. Thanks to the proliferation of low-cost laptops, tablets, and smartphones—and the rise of state and district high-access and 1-to-1 programs—teaching and learning is no longer limited to the confines of a school building or a school day.

To reach the goal of universal broadband access by students and educators, as outlined in this report, SETDA recommends the federal government, states, and districts take responsibility for ensuring easy access to robust broadband connectivity outside of schools including, but not limited to, the home and such publicly accessible institutions as libraries and community centers. Existing inequities in out-of-

school access to broadband within and across school districts, if left unaddressed, will only serve to limit student-learning opportunities and widen existing gaps in student achievement and attainment.

Recommendation 3: Build State Leadership

State leadership is essential to the process of providing adequate and equitable bandwidth. SETDA recommends all states provide direct leadership in the development and implementation of programs to provide adequate and equitable bandwidth to K-12 schools, homes, and publicly accessible institutions, such as libraries and community centers. State leadership could entail expanding broadband coverage via the implementation of cost-effective state broadband networks and working in partnership with school districts to leverage federal and public-private partnership programs in support of a state's broadband needs.

Recommendation 4: Advocate for Federal Funding

The U.S. ranks 15th among industrialized nations in the availability of high-speed Internet access.[53] Bandwidth to homes and schools in Taiwan, France, South Korea, Sweden, and Japan is generally greater and more widely available than it is in the U.S., because the governments of those countries support national efforts to increase broadband access at affordable prices, including public WiFi.[54] For example, some areas of Seoul provide commercial Internet speeds of more than 100 Mbps for merely $30 per month. With this type of speed, a consumer can download an entire HD movie in five minutes—a process that can take two hours or more in the U.S., even in densely populated cites. Yet the South Koreans pay less than U.S. citizens do for Internet service.

To reach the goals outlined in this report, additional resources will be required, and the federal government is uniquely positioned to build upon the success of the E-Rate program to help address these needs for education. SETDA recommends the federal government increase funding options to support a) states in implementing and maintaining high-speed broadband, statewide networks, b) districts and schools in increasing bandwidth capacity, c) communities in providing access points at anchor institutions, including but not limited to, libraries and community centers, and d) low-income families access to broadband at home.

Further resources should be considered for the currently under-funded E-Rate program, in addition to further resources for related programs that can serve to support universal broadband access at school and in homes. To maximize the cost-effectiveness of the E-Rate program, the FCC should work with applicants to make E-Rate more efficient by developing a more streamlined application process for applicants to apply without the need to hire consultants.

The Challenge

While broadband access is currently proliferating in K-12 environments, evolving educational needs are, or soon will be, straining existing bandwidth capacities. The need for increasing bandwidth over the next few years is clear, not only as a means of accommodating those coming changes, but as core infrastructure for future innovations.

The recommendations in this paper focus on supporting an educational ecosystem that sparks innovation, prepares students for college and careers, and allows our teachers and students to exploit the full spectrum of online educational content and evolving best practices available today to every nation via the Internet.

Other challenges remain to be addressed and questions answered. How do we reach persistently underserved and unserved communities with broadband services? How can we best leverage private broadband to help the public good? How can we exploit the potential of 3 G/4 G wireless networks to provide more affordable connections? How do we make the most of the Internet2 for K-12?

To compete globally and develop the innovators our country needs to lead the world, *all* of our students must have access to adequate bandwidth in the classroom, in the home, and wherever learning takes place, regardless of their economic status or geography.

APPENDIX A: TERMS AND DEFINITIONS

Bits and Bytes

Bits and bytes are both units of digital information. A bit is the basic element; a byte is equal to eight bits. The terms kilobyte (KB), megabyte (MB), and gigabyte (GB) are used to indicate the size of a file or a program. The terms kilobit (Kb), megabit (Mb), and gigabit (Gb) are used to convey the rate at which data are transferred over a network, i.e., megabits per second, or Mbps.

Kilobit per second (Kbps) = 1,000 bits per second
Megabit per second (Mbps) = 1,000 Kbps
Gigabit per second (Gbps) = 1,000 Mbps

Speed vs. Capacity

A 1 Mbps broadband connection is "faster" than a 1 Kbps connection which means that it has a greater capacity to carry data. The 1 Kbps connection can deliver a maximum of 1,000 bits of information to your computer from the Internet in a second; a 1 Mbps connection can deliver 1,000 KB in a second. Although the bits are moving at the same speed (more or less), one connection delivers more in the same amount of time, so it feels faster to the end user. This capacity is referred to as *bandwidth.*

Throughput

The actual amount of data that gets transmitted from a PC, through the collection of networks known as the Internet, to the web server—per second—is what is known as *throughput*. Throughput rates vary, depending on traffic and other factors, but it will always be lower than the speed quoted by the ISP providing the connection. Think of that number as the fastest possible speed under ideal circumstances.

Cloud Computing

The term "cloud computing" refers to a computing model in which data, applications, and other computing resources are available on the Internet from just about any connected device. Another way to think of it: It's computing delivered as a service.

APPENDIX B: SELECT FEDERAL FUNDING SOURCES

Funding strategies for the implementation and upgrade of broadband systems should include consideration of partnerships with others in the state and community to aggregate demand and create economies of scale.

E-Rate

The primary source of federal funding for bandwidth upgrades in K-12 continues to be the Schools and Libraries program, better known as E-Rate. The FCC is mandated by Congress to use a set-aside portion of revenues from phone companies, paging service companies, and some VoIP service companies to provide eligible K-12 public schools and libraries with discounts of between 20 and 90% on approved telecommunications, Internet access, and internal connections costs. According to the Software & Information Industry Association (SIIA),[55] the principal trade association for the software and digital content industries, more than $59 billion in E-Rate funding was requested between 1998 and 2010. E-Rate provides critical subsidies to support broadband in K-12.

E-Rate discounts are based on the number of students eligible for the National School Lunch Program. Schools and libraries in low-income urban communities and rural areas qualify for higher discounts.

In 2010, the FCC extended the E-Rate program to allow states and local governments to use these federal funds to provide the general public with access to the Internet facilities of schools and public libraries by permitting them to remain open after hours. The revisions also allowed the annual cap on E-rate spending to grow by the rate of inflation, and it allowed non-telecommunications providers (such as the state networks mentioned above) to use E-rate for fiber-based services for schools and libraries.

Connect America Fund

In November 2011, the FCC approved the creation of the new Connect America Fund (CAF),[56] which effectively transformed the commission's outdated universal service and inter-carrier compensations systems into a new service aimed at rural broadband users. At the time the FCC called it "the most significant policy step ever taken to connect all Americans to broadband." The goal of the fund is to help seven million rural Americans connect to high-speed Internet and voice by 2016.

ARRA EETT

In 2009, U.S. Congress passed the American Recovery and Reinvestment Act (ARRA), appropriating more than $90 billion to education, with $650 million allocated specifically for technology. SETDA has published 28 case studies highlighting state and district use of ARRA funds to support technology programs, many of which include high-access programs that increased bandwidth to support the new hardware.

Broadband Technology Opportunity Program (BTOP)

Administered by the Department of Commerce's National Telecommunications and Information Administration (NTIA), the Broadband Technology Opportunities Program (BTOP) was a game-changing program for many states that had been lacking broadband connectivity. It provided $4.7 billion in grant funds to support the deployment of broadband infrastructure in unserved and underserved areas, to enhance broadband capacity at public computer centers, and to encourage "sustainable adoption of broadband service."

The program, launched in 2009, provided funding for projects deploying new or improved broadband Internet facilities, such as laying new fiber-optic cables or upgrading wireless towers, and connecting such community anchor institutions as schools, libraries, hospitals, and public safety facilities. "These networks help ensure sustainable community growth," the NTIA states on its website, "and provide the foundation for enhanced household and business broadband Internet services."

The program also provided funds "to establish new public computer facilities or upgrade existing ones that provide broadband access to the general public or to specific vulnerable populations, such as low-income individuals, the unemployed, seniors, children, minorities, and people with disabilities."

The focus of the program was increased broadband Internet usage and adoption among "vulnerable populations where broadband technology traditionally has been underutilized." Many projects include digital literacy training and outreach campaigns to increase the relevance of broadband in people's everyday lives.[57]

For example, thanks to the "Sparking Broadband Use in the Eastern Upper Peninsula of Michigan" project (supported by both ARRA EETT and BTOP funding), broadband was extended into the district's rural communities. The program is bridging what had been an expanding digital divide between rural and urban residents by providing opportunities to students and their parents to access educational resources, both in school and at home or in community centers.

These investments must also be fully leveraged to help increase and maintain broadband access. The initial program helped to lay the fiber and provide access but leaders must work to support the use of this broadband now available.

APPENDIX C: REFERENCES

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